CLAIMS

What is claimed is:

1. A self-encoding analytic chemical sensor array comprising:

a population of beads dispersed on a substrate, said population encoded with at least one reporting dye;

a plurality of separate subpopulations of beads contained within said population, each subpopulation of beads comprising a characteristic bead matrix material infiltrated with at least one reporting dye, which said reporting dye, in combination with said characteristic bead matrix material, has a first characteristic optical response signature when subjected to excitation light energy in the presence of a reference analyte and, which said reporting dye, in combination with said characteristic bead matrix material, has a second characteristic optical response signature when subjected to excitation light energy in the presence of an unknown target analyte;

wherein both the identity and the location of each bead comprising said bead subpopulations in sensor array is determined and recorded upon exposure of said sensor array to said reference analyte while subjecting said bead to excitation light energy.

2. The sensor array described in Claim 1, wherein the reporter dye comprises a fluorescent dye.

3. The sensor array described in Claim 2, wherein the reporter dye comprises a solvatochromic dye and the dye is entrapped within the bead matrix material.

4. The sensor array described in Claim 3, wherein the solvatochromic dye comprises Nile Red.

5. The sensor array described in Claim 1, wherein the beads are encoded with a predetermined ratio of at least two reporter dyes.

6. The sensor array described in Claim 1, further comprising a chemical functional roup attached to a surface of at least one subpopulation of beads.

7. The sensor array of Claim 6 wherein said reporting dye provides only said first characteristic optical response signature to decode said array and said second characteristic optical response signature in the presence of an unknown target analyte is provided by an additional reporter dye which responds only in the presence of an unknown target analyte.

8. The sensor array described in Claim 6, wherein the addition of said chemical functional group modifies the characteristic optical response signature of said bead subpopulation, thereby creating a new self-encoding bead subpopulation in said array.

9. The sensor array described in Claim 6, wherein the chemical functionalities of the beads support sites for hybridization.

10. The sensor array described in Claim 1, wherein the substrate comprises a distal end of an optical fiber bundle.

11. The sensor array of Claim 1, wherein the substrate comprises etched microwells at a distal end of individual fibers in an optical fiber bundle.

12. The sensor array of claim 11, wherein the etched wells form a cavity which is larger than the bead diameter and the bead is essentially disposed within said cavity.

13. The sensor array of claim 12 wherein said cavity is no greater than 5 um in diameter.

14. The sensor array of claim 1 wherein the average bead diameters are less than 4 um.

15. The sensor array of claim 1 wherein the characteristic bead matrix material is an organic material selected from the group consisting of polymers and copolymers.

16. The sensor array of claim 15 wherein the organic material swells upon contact to a target analyte.

17. The sensor array of claim 1 wherein the characteristic bead matrix material is an inorganic material selected from the group consisting of porous silicas, aluminas and zeolites.

18. A method for reducing the signal-to-noise ratio in the characteristic optical response signature of a sensor array having a subpopulations of array elements, comprising:

decoding the array so as to identify the location of each sensor element within each sensor subpopulation within the array;

measuring the characteristic optical response signature of each sensor element in the array;

adjusting the baseline of said optical response signature for each sensor element in said array;

summing the baseline-adjusted characteristic optical response signature of all sensor elements within each of said sensor subpopulations; and

reporting the characteristic optical response signature of each sensor subpopulation as a summation of said baseline-adjusted characteristic optical response signatures of all sensor elements within each of said subpopulations.

19. The method of Claim 18, wherein the signal-to-noise ratio is increased by a factor of at least ten.

20. The method of Claim 19, wherein an analyte detection limit is reduced by a factor of at least 100.

21. A method for amplifying the characteristic optical response signature of a sensor array having subpopulations of array elements, comprising:

decoding the array so as to identify the location of each sensor element within each sensor subpopulation within the array;

measuring a characteristic optical response signature of each sensor element in the array;

adjusting the baseline of said optical response signature for each sensor element in said array;

summing the baseline-adjusted characteristic optical response signature of all sensor elements within each of said sensor subpopulations; and

reporting the characteristic optical response signature of each sensor subpopulation as a summation of said baseline-adjusted characteristic optical response signatures of all sensor elements within each of said subpopulations.

22. The method of Claim 21, wherein the signal is amplified by a factor of at least fifty.

23. The method of Claim 22, wherein an analyte detection limit is reduced by a factor of at least 100.

24. A sensing apparatus comprising:

a sensor array which comprises, a population of beads dispersed on a substrate, said

population encoded with at least one reporting dye, a plurality of separate subpopulations of beads contained within said population, each subpopulation of beads comprising a characteristic bead matrix material infiltrated with at least one reporting dye, which said reporting dye, in combination with said characteristic bead matrix material, has a first characteristic optical response signature when subjected to excitation light energy in the presence of a reference analyte and, which said reporting dye, in combination with said characteristic bead matrix material, has a second characteristic optical response signature when subjected to excitation light energy in the presence of an unknown target analyte, wherein both the identity and the location of each bead comprising said bead subpopulations in said sensor array is determined and recorded upon exposure of said sensor array to said reference analyte while subjecting said bead to excitation light energy;

an optical fiber bundle, comprising a plurality of discrete individual fibers, each of said fibers in said bundle optically cooperating with and in optical communication with a discrete sensor bead in said sensor array;

an excitation light energy source in optical communication with a proximal end of said optical fiber bundle, said light source providing excitation light energy to said proximal end and said fiber bundle conveying said excitation light energy through said discrete fibers to a plurality of discrete sensor beads, wherein the light conveyed by each fiber is coupled to a specific bead element in said sensor array; and

an emission light energy detection means in optical communication with said proximal end of said fiber bundle, said detection means measuring light emitted from each fiber in said bundle at said proximal end in response to an analyte, wherein the emitted light which is

conveyed by each fiber is produced from the response of a discrete sensor bead coupled to said fiber at a distal end of said fiber.

25. The sensing apparatus of Claim 24 further comprising a neural network system for associating the emitted light response of said discrete sensor beads and a characteristic image of the emitted light response of the entire sensor array to a target analyte for the detection and identification of said analyte.

26. A sensing method comprising:

assembling a sensor array which comprises, a population of beads dispersed on a substrate, said population encoded with at least one reporting dye, a plurality of separate subpopulations of beads contained within said population, each subpopulation of beads comprising a characteristic bead matrix material infiltrated with at least one reporting dye, which said reporting dye, in combination with said characteristic bead matrix material, has a first characteristic optical response signature when subjected to excitation light energy in the presence of a reference analyte and, which said reporting dye, in combination with said characteristic bead matrix material, has a second characteristic optical response signature when subjected to excitation light energy in the presence of an unknown target analyte, wherein both the identity and the location of each bead comprising said bead subpopulations in said sensor array is determined and recorded upon exposure of said sensor array to said reference analyte while subjecting said bead to excitation light energy; coupling said sensor array with an optical fiber bundle, comprising a plurality of discrete

individual fibers, each of said fibers in said bundle optically cooperating with and in optical communication with a discrete sensor bead in said sensor array;

illuminating a proximal end of said optical fiber bundle with an excitation light energy source in optical communication with said proximal end, said light source providing excitation light energy to said proximal end and said fiber bundle;

conveying said excitation light energy through said discrete fibers of said bundle to a plurality of discrete sensor beads, each of said sensor beads positioned at a distal end of each of said fibers, wherein the light conveyed by each fiber is coupled to a specific bead element in said sensor array; and

detecting the light emitted from each fiber in said bundle by an emission light energy detection means in optical communication with said proximal end of said fiber bundle, said detection means measuring light emitted from each fiber in said bundle at said proximal end in response to an analyte, wherein the emitted light which is conveyed by each fiber is produced from the response of a discrete sensor bead coupled to said fiber at a distal end of said fiber.

27. The sensing method of Claim 26 further comprising a applying a neural network system for associating the emitted light response of said discrete sensor beads and a characteristic image of the emitted light response of the entire sensor array to a target analyte for the detection and identification of said analyte.

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